Air Force Research Laboratory

Modular Optics Needs

Presented at Mirror Technology Days 2010

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Summary

- The Problems
  - Rapid Delivery of Capability
  - Cost
- Needs (not solution dependent)
- Possible Solution – Modular Optics
  - Advantages
  - Disadvantages
  - Unanswered questions

The Problems

- **Cameras take time to develop and field.**
  - **Operationally Responsive Space needs cameras that can be assembled rapidly to meet a variety of mission needs**
- **Cameras for space are expensive**
- **Causes**
  - **Number of systems acquired is small**
  - **Missions can be challenging**
  - **Alignment difficult and time consuming, especially for cooled cameras**
  - **Calibration**
  - **Non-Recurring Engineering (NRE)**

Problems with NRE

- **Never perfect**
  - **Often relearn old lessons each time**
    - **Stray light management**
    - **Alignment**
    - **Thermal stability and control**
- **Management and engineering disadvantages**
  - **Development**
    - **Managing requirements**
    - **Tracking action items**
    - **Design**
    - **Design Reviews**
    - **Assembly, integration, and testing**
    - **Verification and validation**
  - **Must complete this with new hardware that may fail at each step of the process**

Camera Needs
(the short list)

- Capable of collecting data useful to the warfighter
- Can be tested and integrated with a spacecraft in a short time (less than 6 days) by non-experts
- Withstands all transport, launch, and on-orbit environments
- Maintains optical performance throughout operational life
- Has a means to easily verify required performance like alignment and calibration
- Provides its own pointing information
- Is easy to calibrate on the ground and in orbit

Modular Optics

Potential solution and advantages

- **Modular optics may be one way to solve the timeline and cost problem**
- **Advantages:**
  - **Have the potential to reduce timelines by permitting the mating of a few common components with mission specific components to satisfy a range of missions**
  - **Can potentially reduce costs by eliminating individual component development; an expensive and time-consuming part of the system engineering process.**
  - **May be more likely to meet system requirement because the capabilities of the individual components are known beforehand, whereas newly designed components may not meet their target requirements.**
  - **Could help cope with technology advancement by allowing component swaps without system redesign.**

Modular Optics
Disadvantages

- **Disadvantages**
  - **Only eliminate part of the systems engineering process. Refining requirements; design; design reviews; assembly, integration, and testing; and verification and validation are all still required.**
  - **May not sell. It may be harder to sell a "good enough" system when you could have the latest technology in a tightly integrated package.**
  - **Don't solve the quantity problem. The current market for cameras in space is still small. However, I believe this is driven by cost. If the costs were lower, quantities should go up. More imagery is always desired.**
  - **May not be able to meet mission requirements with available components.**
  - **May be more challenging to align.**

Unanswered Questions

- **What level of modularity is most useful?**
  - **Remains unanswered**
  - **Cameras are already modular**

> Integrators already combine focal plane arrays, optical elements, optical benches, sunshades, cryocoolers, electronics, etc. from multiple vendors.

  - **Is there a way to create common interfaces to allow interchangeability?**
  - **Is interchangeability even desirable?**
    - **Does it merely complicate things like alignment and thermal management that are easier and cheaper to handle in a more tightly integrated system?**

Prior Efforts

- **Operationally Responsive Space finished a modular optics study in 2009.**
  - **“EO/IR Modular Architecture Trade Study”**
  - **Will be available in DTIC shortly:**
    - **Vol I (Dist C, US Government and contractors, export controlled)**
    - **Vol II (Dist B, US Government only)**
    - **Vol III (classified)**
    - **Corporate author: “DRS SENSORS AND TARGETING SYSTEMS INC”**

Other Relevant Prior Efforts

- **These recent efforts addressed the rapid calibration and checkout of cameras:**
  - **“Simplified, Rapid Calibration of Electro Optical Payloads”**
    - **Available in DTIC: ADXXXX**
    - **Dist C, US Government and contractors**
    - **Corporate author: “UTAH STATE UNIV LOGAN UT SPACE DYNAMICS LABORATORY” or “SPACE DYNAMICS LABORATORY”**
  - **“Rapid On-Orbit Checkout of Space Systems”**
    - **Available in DTIC: ADXXXX**
    - **Dist C, US Government and contractors**
    - **Corporate author: “SCIENTIFIC ADVISORY BOARD (AIR FORCE) WASHINGTON DC “**

Current SBIR Topics in Pre-Solicitation

- Rapid alignment of electro-optical payloads to meet short timelines
- Lightweight mirrors
- All-sky proximity sensor technology that focuses specifically on sensing with the sun within the field of view
  - Component level technology development rather than system level

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